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(12) (19) (CA) **Demande-Application**

(21) (A1) **2,263,240**
(86) 1997/08/15
(87) 1998/02/26

BEST AVAILABLE COPY

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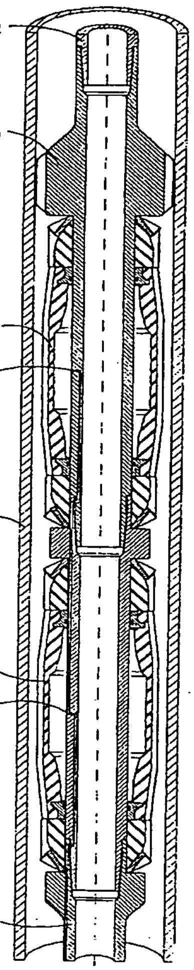
(51) Int.Cl.[6] E21B 43/10, E21B 19/22
(30) 1996/08/16 (08/698,662) US

(54) **PROCEDE DE POSE DE TUBAGE DANS UN PUITS DE FORAGE**

(54) **METHOD FOR CASING A WELLBORE**



(57) On installe un tubage (15) dans un puits, à l'état replié, en le déroulant depuis un touret (87). Deux colonnes de tubage (27, 29) s'étendent en continu dans le tubage replié. Une des colonnes (27) est reliée à un sabot en ciment (19) au niveau de l'extrémité inférieure du tubage. Un outil d'ouverture (31) est prévu au-dessus du sabot en ciment (19) et comporte un piston (33). L'autre colonne (29) s'étend jusque dans une chambre de

(57) Casing (15) is installed in a well in a folded collapsed condition by uncoiling it from a reel (87). Two strings of tubing (27, 29) extend continuously through the collapsed casing. One of the strings of tubing (27) is connected to a cement shoe (19) at the lower end of the casing. An opening tool (31) is located above the cement shoe (19) and includes a piston (33). The other string of tubing (29) extends to a pressure chamber (35) that is

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : E21B 43/10, 19/22 — A1

(11) International Publication Number: WO 98/07957

(43) International Publication Date: 26 February 1998 (26.02.98)

(21) International Application Number: PCT/IB97/00994

(22) International Filing Date: 15 August 1997 (15.08.97)

(30) Priority Data:
08/698,662 16 August 1996 (16.08.96) US

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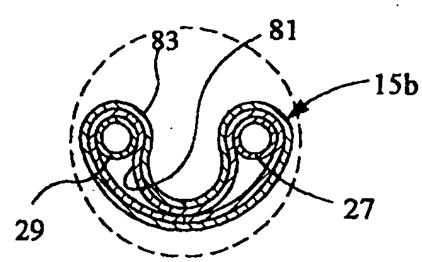
(81) Designated States: AU, BR, CA, CN, JP, MX, NO, RU, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: METHOD FOR CASING A WELLBORE

(57) Abstract



Casing (15) is installed in a well in a folded collapsed condition by uncoiling it from a reel (87). Two strings of tubing (27, 29) extend continuously through the collapsed casing. One of the strings of tubing (27) is connected to a cement shoe (19) at teh lower end of the casing. An opening tool (31) is located above the cement shoe (19) and includes a piston (33). The other string of tubing (29) extends to a pressure chamber (35) that is between the piston (33) and the cement shoe (19). After the casing (15) is lowered with a running tool to the desired depth, cement is pumped down the first string of tubing (27), which flows back up the annulus surrounding the casing. A liquid is then pumped down the second string of tubing (29) into the pressure chamber (35), causing the piston (33) to push the conical forming head upward (38, 39) relative to the casing (15) and the strings of tubing (27, 29). The forming head (38, 39) opens the casing (15) from the collapsed condition into a cylindrical configuration. The running tool (55) retrieves the strings of tubing and the opening tool (31) at the conclusion of the opening and drifting process.

casing while being inflated and a lack of cost effectiveness due to the cost of composite material compared to steel.

WO 9622452 discloses a conical expanding mandrel used to increase the diameter in situs of steel slotted pervious casing by vertical pull of the mandrel or by radial hydraulic expansion. Mechanical pull of a mandrel inside a downhole casing is facing reaction problem and the section by section hydraulic expansion is not really practical for extended casing length.

Although the known methods developed by the applicant or others offers theoretical solution to provide improved casing solutions, there remains a need for a system and method for casing economically well offering the cost effectiveness of steel pipe with the installation advantages of (US 5,337,823) or expandable casing (WO 9622452).

Disclosure of Invention

In this invention, a metal strip plate is formed in a generally tubular configuration, and welded longitudinally with at least one string of continuous tubing inserted during the manufacturing process. Alternatively circular pipe sections about forty feet long are welded together and strings of tubing are threaded inside. The casing is then collapsed with the tubing located therein and wound on a small reel due to its small height by comparison to its nominal diameter. The upper and lower end portions of the casings are generally formed in a somewhat cylindrical configuration. An opening tool is located in the lower end cylindrical portion. The opening tool has a piston and a conical forming head located above the piston. A pressure chamber is created below the piston in the lower end portion of the casing.

The casing is deployed from the reel and folded in a horseshoe shape prior to entering the well. When the casing has reached the proper depth, a fluid is pumped down the tubing into the pressure chamber to open the casing into a cylindrical shape. The fluid pressure acts against the piston to push the opening tool upward. This causes the head of the opening tool to form the casing from the collapsed/folded configuration into a cylindrical configuration. The forming tool and the tubing are then pulled from the casing.

Preferably, two strings of tubing are installed in the casing while it is being manufactured. One of the strings of tubing serves to pump a cement slurry down through a cement shoe located at the lower end of the casing. The cement flows back up the annulus surrounding the casing to cement the casing in place. Then fluid is pumped down the other string of tubing to open the casing.

Also after the opening tool reaches the upper end of the casing, a forging tool is used to expand the upper end cylindrical portion of the casing into a metal to metal sealing engagement with the lower end of the previously cased section of the well. In the preferred embodiment, this involves releasing the running tool from the upper end of the casing after the collapsed portion of the casing has been expanded, then lowering the forging tool located above the running tool into the casing. Fluid is then pumped down to radially forge the upper end of the casing into engagement with the lower end of the previous one.

The opening tool includes a forming head with a conical body with flutes. Balls roll along the flutes in rolling engagement with the casing wall as it is being open to a cylindrical configuration. The balls force the opening of the casing as they roll along

Figures 1A-1D with a dual layer configuration.

Figure 19 is a schematic view illustrating the collapsed casing of Figures 1A-1D being uncoiled from a reel, folded in a horse shoe shape and lowered into a well.

Figure 20 is a flattened sectional view of the casing of Figure 19, shown along the line 20-20 of Figure 19.

Figure 21 is a folded sectional view of the casing of Figure 19, shown along the line 21-21 of Figure 19.

Figure 22 is a schematic view illustrating valves for controlling the flow of fluids to the installation apparatus of Figures 1A-1D.

Figure 23 and 24 are isometric views illustrating an alternative design for the opening tool including expander segments.

Best Mode for Carrying Out the Invention

Referring to Figures 1A-1D, the well illustrated has a cased section 11 which has already been cemented in place and an open hole section 13 which extends below cased section 11 to the target depth. A continuous string of casing 15 according to the invention is shown in place in the well with a lower end portion 15a at the lower end of the well open hole section 13. Casing 15 has an intermediate portion 15b that extends from the lower end portion upward, typically several thousand feet, to an upper end portion 15c. Upper end portion 15c overlaps the lower portion of cased section 11. Casing lower and upper end portions 15a, 15c each are somewhat cylindrical with axially extending corrugations 17 as shown in Figure 5. Corrugations 17 are straight axially extending channels on both the inner and outer diameters of casing, providing inward protruding valleys 17a alternating with outward protruding peaks 17b. Intermediate portion 15b, shown in Figure 4, is collapsed and folded, having a bight 18 that curves inward and touches the opposite side, which is generally arcuate when lowered into the wellbore.

Referring to Figure 1D, a cement shoe 19 is located at the lower end of casing lower end portion 15a. Cement shoe 19 provides a end cap for casing 15 and is made of drillable material with a cementing port 20 extending axially through it. A metal stinger 21 engages sealingly into the upper portion of cementing port 20. Stinger 21 is a tubular member having a conduit 23 for pumping down a cement slurry through cementing port 20 which flow back up the annulus space surrounding the casing 15, as indicated by the arrows. Stinger 21 has also some flow ports 25 which are isolated from conduit 23 and lead to the exterior of stinger 21.

A cement slurry tubing 27 extends continuously through casing 15, and has its lower end coupled to stinger 21 for connecting with conduit 23. Similarly, a fill-up tubing 29 extends continuously through casing 15 and has its lower end coupled to stinger 21 for delivering fluid to ports 25. Tubing strings 27, 29 are, conventional metal coiled tubing strings of about one inch in diameter.

An opening tool 31 is housed in casing lower end portion 15a, shown in Figure 1C, above stinger 21. Opening tool 31 includes on its lower end a piston 33. Piston 33 is an elastomeric cup sliding seal, which has straight axially extending grooves on its exterior for meshing with the corrugations 17 of casing lower end portion 15a. Piston 33 has a packing element 33a to seal around tubing strings 27, 29. A pressure chamber 35 is located in the space surrounding stinger 21 above cement shoe 19 and below piston 33. In the running-in position, as shown in Figure 1D, pressure chamber 35 is at its

running string 72 to place the J-pin 61 in the second leg 63b. This causes sleeve 56 to rotate an increment, as shown by the arrow in Figure 3B, disengaging the threads on outer sleeve 56 from threads 57. Bands 58a on outer sleeve 56 align with peaks 17b, allowing running tool 55 to be lowered into casing upper end portion 15c.

Running tool 55 has a main supply passage 64 connected to the passage in the lower part of packer string 69 which extends into inner body 59. A cement slurry passage 65 (Fig. 3A) connected to tubing string 27 is located in running tool 55 and can be connected to the lower end of main supply passage 64. Similarly, a fill-up passage 67 connected to tubing string 29 can be connected to the lower end of main supply passage 64..

Inner body 59 of running tool 55 is connected to the packer string 69 by threads. The upper part of packer string 69 features a centralizer 70. Two or more forging packers 71 are mounted on the packer string 69 between centralizer 70 and inner body 59. Forging packers 71, when supplied with high internal pressure from a down hole pressure multiplicator (not shown), will inflate and radially expand to plastically forge the upper end of casing upper end portion 15c, as shown in Figure 12. Hydraulic passages 73, extending through packer string 69, can be connected via pressure multiplicator to lower end of main supply passage 64 within running tool inner body 59. Paker string 69 is connected at centralizer 70 to a the running string 72 which extends to the surface. Preferably, running string 72 is another string of coiled tubing approximately two inches in diameter. Packers 71 have external axial grooves 74 which will align with valleys 17a of casing upper end portion 15c when packers 71 are lowered into upper end portion 15c with the centralizer 70 landed on top of the casing 15c as shown in Figure 12.

Referring to Figure 22, in the preferred embodiment, electrically actuated valves 75, 77 and 79 are mounted in running tool inner body 59 (Fig. 1B). Valve 75 is in slurry passage 65 and opens and closes flow to tubing 27. Valve 77 is in opening fluid passage 67 for opening and closing flow from main supply passage 64 to tubing 29. Valve 79 is in pressure passage 73 for opening and closing pressure fluid from main supply passage 64 to forging packers 71 (Fig. 1A). Electrical valve control wires (not shown) extend through coiled running string 72 to the surface to a control panel. A small accumulator (not shown) supplies hydraulic fluid to valves 73, 77, 79 to open and close them when electrically actuated. Pumps 80 on the surface, which could be either cement or mud pumps are used for delivering pressure fluid down main supply passage 64.

Referring now to Figure 15, casing 15 is fabricated by drawing a first metal strip 81 from a reel and bending two edges down around two laterally spaced apart, parallel continuous strings of coiled tubing 27, 29. As shown in Figure 16, the edges are bent over and welded at seam 82. The upper side is bent into a concave shape touching seam 82, while the lower side is flat. Then, a second strip 83 is drawn from a reel and bent to have upturned edges. As shown in Figure 17, second strip 83 is then bent by rollers around first strip 81 while first strip 81 is in the configuration shown in Figure 16. Rollers then bend the upper side of strip 83 into a concave shape as shown in Figure 20. Casing 15 thus is double-walled and has a flat side 85 that extends between parallel tubing strings 27, 29, generally tangent to outer diameter portions of tubing strings 27, 29.

The use of two walls for casing 15 reduces the amount of strain that would

the surface.

After pumping the calculated volume of cement slurry, a selected volume of flushing fluid will be pumped down cement slurry tubing 27. The volume is selected to be just the amount needed to push cement slurry from conduit 72, tubing 27 and stinger 21 into the open borehole, but substantially no more. The valve 75 is then closed and valve 77 is open. Drilling fluid is pumped down conduit 72, which flows through passages 64, 67 and down fill-up tubing 29. The fluid flows out ports 25 into pressure chamber 35, shown in Figure 1D.

As shown in Figure 8B, the fluid pushes upward on piston 33, which slides upward relative to tubing strings 27, 29. Piston head 37 pushes balls 43 from the space in sleeve 48 upward into passages 45, as can be seen by comparing Figure 1D with Figure 8A. Once in contact with flange 50, the force exerted by piston head 37 begins to push the opening tool 31 upward while tubing strings 27, 29 remain stationary. Due to the engagement of balls 43 with head 39 and casing lower end portion 15a, balls 43 are forced to roll down the inclined flutes 41, pushing the valleys 17a outward to first remove corrugations 17 of the casing lower end 15a and open the intermediate portion 15b.

After a short distance, all of the balls 43 will be in engagement with conical body 39, as shown in Figure 8A. Upper end 51 will move upward into the intermediate portion 15b. Balls 43 will open casing from the collapsed folded configuration of Figure 9 to the cylindrical configuration of Figure 10. During the casing expansion process, the annulus surrounding casing intermediate portion 15b decreases, pushing cement slurry 92 upward, and returns will flow up into the channel spaces between corrugations 17 of casing upper end portion 15c and cased section 11. Some of the cement slurry 92 will flow out above running tool 55 to insure a proper seal between casings when they will be later forged together. As forming tool 31 moves upward, the volume of pressure chamber 35 increases. This process will continue for the entire length of the casing which could exceed several thousand feet.

Eventually, forming tool 31 will reach casing upper end portion 15c. At this point, balls 43 will push outward on valleys 17a to round the corrugated configuration 17 into a cylindrical configuration in the same manner as at casing lower end portion 15a. Forming tool 31 will eventually contact the lower end of running tool 55, which protrudes a short distance into casing upper end portion 15c, shown in Figure 1B.

The running tool 55 will be released from threads 57 by letting running string 72 go down a short distance, then pulling upward. While lowering, tubing strings 27, 29 will spiral slightly along their lengths to accommodate the compression. The downward movement of inner body 59 relative to outer sleeve 56 causes J-pin 61 to move from first leg 63a to second leg 63b. When this occurs, an incremental amount of rotation of sleeve 56 occurs relative to inner body 59. This rotation, as illustrated in Figure 3B, causes threads 57 to disengage from the threads on sleeve 56, releasing running tool 55 from casing upper end portion 15c. Grooves 58 on outer sleeve 56 will now be aligned with valleys 17a.

The operator then again drop running string 72 to place forging packers 71 within casing upper end portion 15c as shown in Figure 12. Because of the alignment of axial external grooves 58 and external grooves 74 (Figs. 1A, 1B) with corrugations 17, outer sleeve 56 and packers 71 will pass downward within casing upper end portion 15c. Centralizer 70 is closely spaced to the inner diameter of cased section 11, and will

changes without departing from the scope of the invention. For example, rather than coiled tubing running string 72, if a hoisting mast is available, conventional drill pipe may be used. In that event, rather than electrically actuated valves, the valving can be accomplished by balls or darts down the conduit 64 to selectively close and open the passages. Also, rather than elastomeric packers for expanding the casing upper end portion, other pressure actuated metal radially expandable members may be employed

(87), the casing has a generally flattened configuration (Fig. 20) and wherein the deploying means (Fig. 19) also comprises bending means for bending the flattened configuration of the casing into an arcuate generally horseshoe configuration (Fig. 21) as the casing (15) is deployed from the reel (87) and prior to entry into the well.

12. The apparatus according to claim 11, wherein there are two strings of tubing (27, 29) located inside the casing at both ends of the flattened configuration (Fig. 20).

13. The apparatus according to claim 1, wherein there are:

a straight upper end portion of the casing (15c) that is generally cylindrical;

a running tool (55);

releasable means (57) for attaching the running tool to the upper end portion of the casing;

means for attaching the running tool to a running string (72) for lowering the casing in the well;

the releasable means releasing the running tool (55) from the upper end of the casing after the casing has been opened into the cylindrical configuration for retrieving the running string (72) and running tool (55).

14. The apparatus according to claim 13, wherein there are:

at least, one string of tubing (29) located inside the casing and the opening tool piston has sealing means (33a) around the tubing.

means for securing the upper end of the string of tubing (27, 29) to the running tool;

means to retain the opening tool on the string of tubing;

the releasable means releasing the running tool (55) from the upper end of the casing for retrieving the running string (72), the opening tool (31) and the string of tubing (27, 29) after the casing has been opened into cylindrical configuration.

15. The apparatus according to claim 1, wherein the well has an upper cased section (11), and wherein the apparatus further comprises means (71, 74) for plastically deforming the upper end of the casing (15c) into engagement with the upper cased section of the well (11).

16. The apparatus according to claim 1, wherein the casing comprises at least two concentric sleeves (81, 83) in tight contact with each other.

17. The apparatus according to claim 3, wherein the corrugated casing straight end portion (15a, 15c) comprises at least two concentric sleeves (81, 83) in tight contact with each other.

18. The apparatus according to claim 1, wherein there are:

first and second strings of tubing (27, 29);

a continuous metal casing (15) having an intermediate portion (15b) formed in a generally flattened configuration (Fig. 20) with the first and second strings of tubing contained therein and laterally spaced apart;

the casing having a generally cylindrical lower end portion (15a);

opening tool (31) which has retractable opening/drifting means;

lowering the casing (15) from the reel (87) into the well and bending the flattened configuration of the casing; and

pumping a fluid down the tubing into the pressure chamber (35), which acts against the piston (33) to push the opening tool (31) relative to the casing (15), causing the forming head (38, 39) to grow to its nominal drifting dimension to open and drift the casing from the collapsed configuration into a cylindrical configuration.

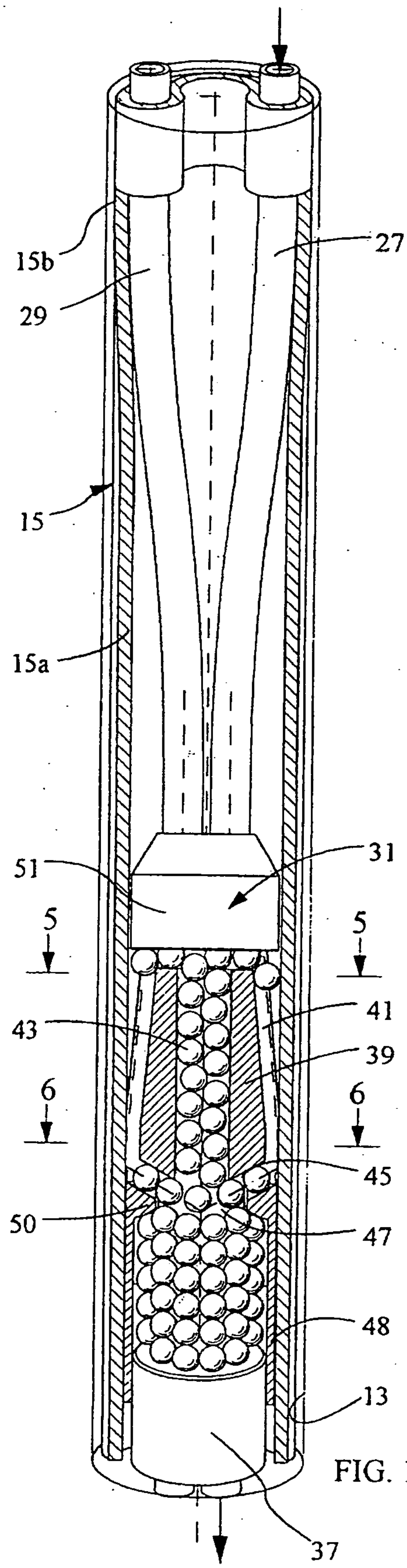


FIG. 1C

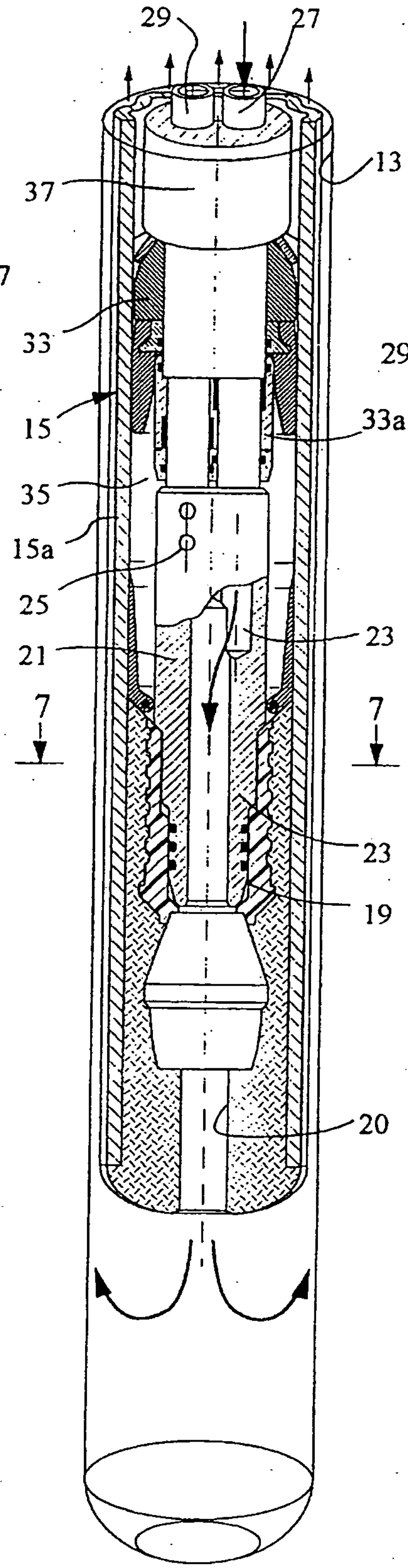


FIG. 1D

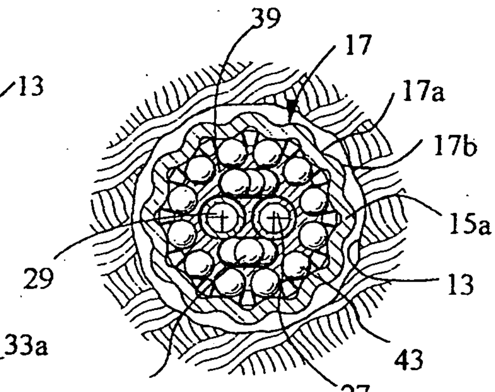


FIG. 5

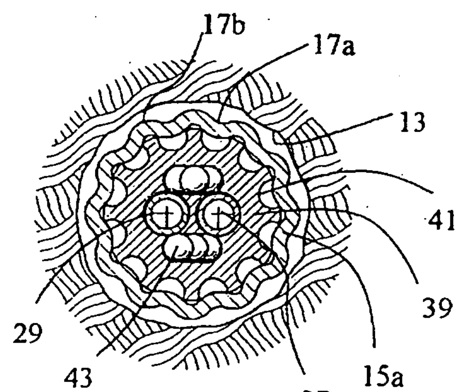


FIG. 6

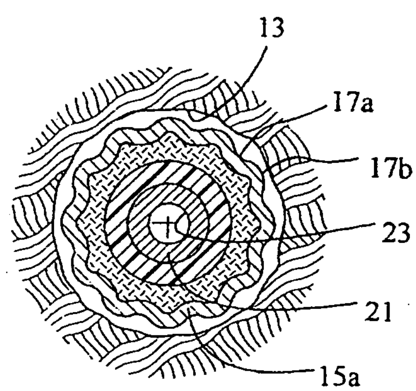


FIG. 7

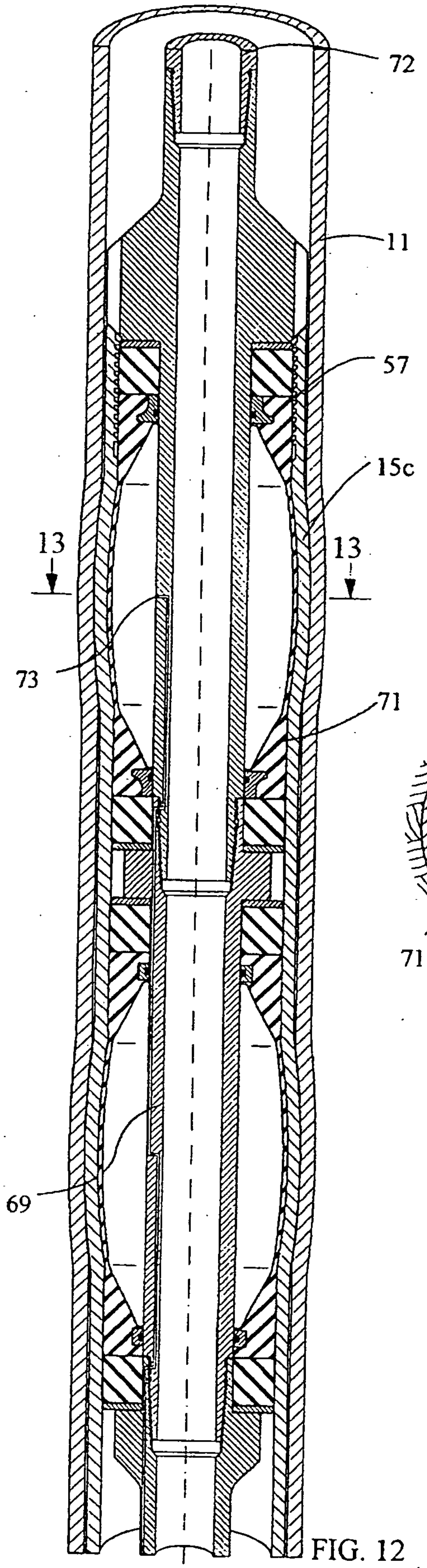


FIG. 12

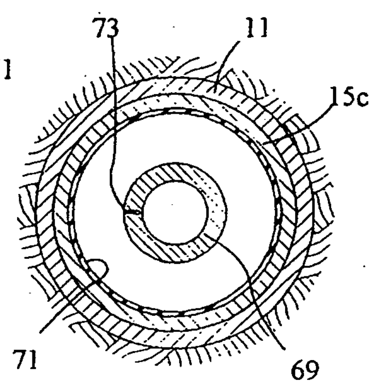


FIG. 13

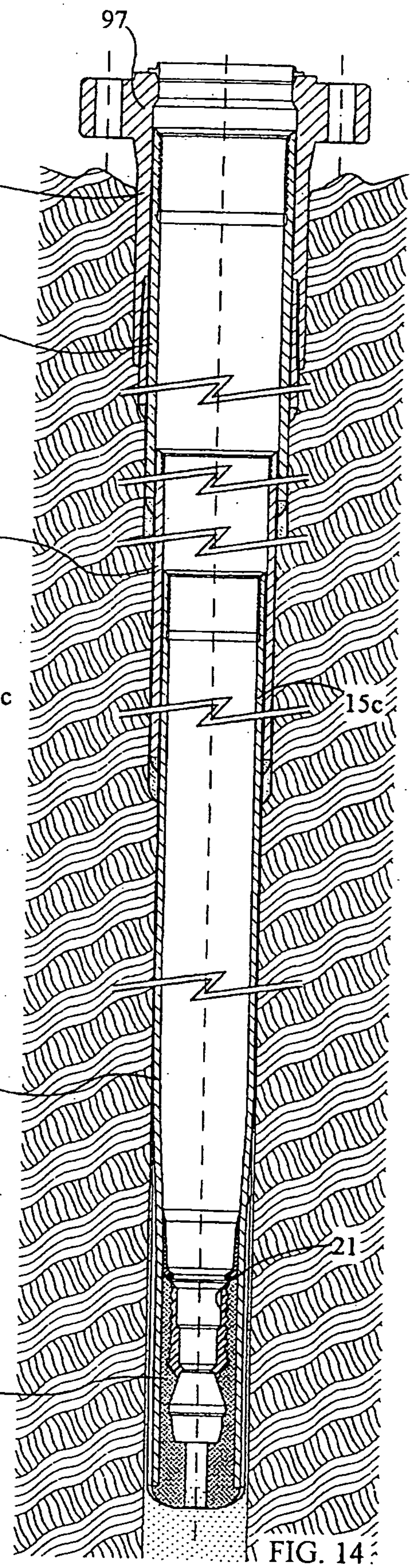
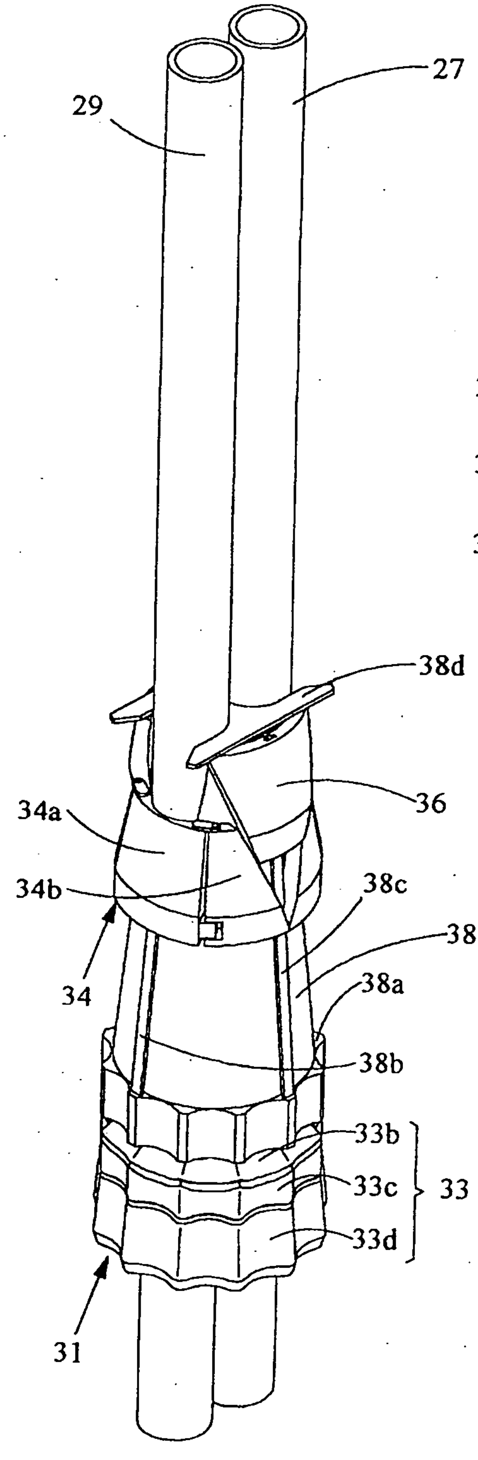


FIG. 14


29
27
38d
34a
36
34b
38c
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33b
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31

FIG. 23

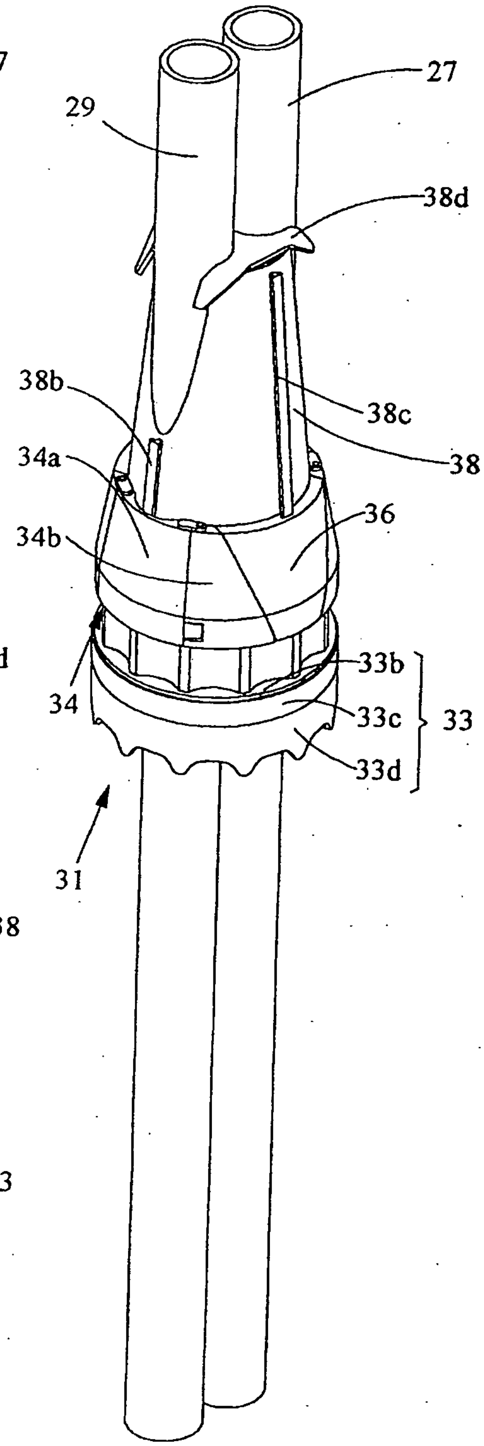
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FIG. 24